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NOAA PROTOCOLS FOR FISHERIES ACOUSTICS SURVEYS AND RELATED SAMPLING IN THE NEFSC

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NOAA Protocols for Fisheries Acoustics Surveys and Related Sampling

Northeast Fisheries Science Center

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Northeast Fisheries Science Center

January 15, 2004

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Introduction

This document provides data collection and operational protocols for acoustical surveys of Atlantic herring (*Clupea harengus*) at the Northeast Fisheries Science Center (NEFSC).

This document is arranged as follows. Center-specific background is given to provide information on NEFSC personnel and general support. Five general categories are defined: system calibration and performance, acoustical backscattering measurements, target strength, acoustical-biological conversions, and sampling (survey) design. Acoustical background and general information for each section and the topics "Definition & Importance", "Error", and "Considerations" are given in the acoustics National Protocol and are not repeated here. The Methods section details specific methods for each of these categories.

Center Background

NEFSC

The Northeast Fisheries Science Center (NEFSC) fisheries acoustics group currently has two FTE's affiliated with the Survey Branch and one FTE affiliated with the Population Dynamic's Branch. Two FTE's are base funded and the other FTE is funded on a congressional budget "line-item". The NEFSC fisheries acoustics group focuses on estimating Atlantic herring (*Clupea harengus*) spawning stock biomass with an annual six-week survey conducted in the fall.

The Atlantic herring acoustical survey employs a systematic parallel design, with inter-transect spacing set at 8 or 10 nautical miles (nmi). The transect spacing is consistent within a survey, but has changed among surveys. This is due to logistic constraints, and the fact that a definitive survey design has not been determined at this time. The extent of the survey encompasses the spawning stock biomass in the Georges Bank region. The S_a values along transects are used to derive relative indices of the herring abundance. The S_a values are extrapolated to the surveyed region using geostatistical methods. The Sa values are converted to abundance by calculating mean herring lengths from trawl catches, converting the mean lengths to target strength (TS) using a generic Atlantic herring TS-Length regression. Biomass estimates are derived by scaling the abundance estimates by an empirical length-weight relationship. Age-based estimates are derived from the age composition of the trawl catches.

Methods

Calibration and System Performance

Calibration

Techniques

Software

NEFSC Protocols

The NEFSC uses the Simrad Lobe program, version EK/EY500 5.XX (date of last revision: 30 October 1995) to calibrate the EK500 echo sounder. The calibration software version and the echo sounder firmware version are documented for all calibrations.

Standard values

Table 1 provides a list of standard values for calibration.

Table 1. Calibration standard values used at the NEFSC. Calibration sphere measurements are the sphere diameter. 'Cu' denotes a copper calibration sphere. Note that the 18 kHz has two spheres listed. Simrad originally recommended the 63-mm sphere. However, after consultation with Neal Williamson (NOAA-Fisheries, AFSC) and Ken Foote (WHOI) during the fall of 2003, the 64-mm Cu sphere was determined to be the optimal sphere. The 64-mm Cu will be used from 2004 on. The 12-kHz echo sounder was replaced in 2002 with the 18-kHz echo sounder.

Frequency [kHz]	Calibration Sphere	EK500 Minimum Target Range [m]	Nominal TS [dB]*
12	45 mm Cu	35	-40.4
18	64 mm Cu	22	-34.4
18	63 mm Cu	22	-34.4
38	60 mm Cu	10	-33.6
120	23 mm Cu	10	-40.4

On-axis sensitivity

NEFSC Protocols

The NEFSC acoustics manual (NEFSC_aqstx-acoustics_manual.doc) details on-axis calibration protocols. The tolerance of the 38-kHz on-axis calibration is ±0.4 dB (G_0: ±0.2 dB).

Transceiver settings are equivalent to those used during the survey.

Beam pattern measurements

NEFSC Protocols

The NEFSC acoustics manual (NEFSC_aqstx-acoustics_manual.doc) details beampattern measurement protocols. The NEFSC does not modify the offset or beamwidth parameters based on the LOBE program. This is due to the concern that the beam pattern parameters derived by the LOBE program are not based on independent measurements of the beam pattern. The LOBE program relies on the angular offsets provided by the EK500 and transducer, which is not an independent measure of the true angular positions.

Transceiver settings are equivalent to those used during the survey.

S_v Calibrations

NEFSC Protocols

The NEFSC acoustics manual (NEFSC_aqstx-acoustics_manual.doc) details S_v calibration protocols. The tolerance of the 38-kHz S_v calibration is ±0.4 dB (G_0: ±0.2 dB).

Transceiver settings are equivalent to those used during the survey.

Oceanographic Data

NEFSC Protocols

A vertical temperature and salinity (CTD) profile is collected prior to calibrations that are conducted offshore. For inshore calibrations, such as those that are conducted at the Woods Hole Oceanographic Institution's pier, either CTD profiles or the 3-m temperature and salinity hull-mounted sensor are used for the physical data. CTD profiles encompass the calibration depths. Refer to the Sampling->Oceanographic Data section for details on operating the CTD.

Temperature and salinity measurements are compared between the CTD profiler and hull-mounted sensors during the calibrations.

Considerations

Remediation

If the 38-kHz TS or S_v gain values (G_0) are outside of the tolerances defined above, the survey will not commence until the cause of the error is resolved. The Simrad manual (Simrad, 1996) provides diagnostic tests to evaluate the EK500 echo sounder.

If temperature and salinity measurements are not comparable between the CTD profiler and hull-mounted sensors, the Fisheries Oceanography Investigation (FOI) and the ship's electronic technician should be contacted to determine the cause of the discrepancy.

System Performance

Techniques

NEFSC Protocols

The 'test' values and passive noise values for the Simrad EK500 echo sounder are documented for every calibration and at the beginning of each survey 'leg' (two-week portion of a survey). Test and passive noise values are documented for the 18, 38, and 120-kHz frequencies.

During the survey, individual target locations in the acoustic beam (EK500 TS Detection Menu) are evaluated to ensure that individual target locations appear in all quadrants.

Considerations

Remediation

Survey operations should be suspended if the 'Test' values are out of tolerance and the cause of the errors diagnosed. The Simrad manual provides diagnostic and evaluation procedures (Simrad, 1996). After the problem is resolved, the survey can continue.

If individual targets do not appear in all quadrants, survey operations should be suspended and the problem diagnosed. After the problem is resolved, the survey can continue.

Data Management

The calibration LOBE data, EK500 telegram data, parameter settings, and associated meta-data are stored on board until such time is appropriate for downloading to a shore-based computer. The LOBE data are stored on the laptop computer that was used for the calibrations. The EK500 telegram data are stored on the backup SCS server, which is RAID configured to minimize potential loss of data. These data are archived by the Data Management Service branch at the NEFSC after the data are downloaded to shore.

Volume Backscattering Measurements (E_i)

Data Collection

Techniques

Echo Sounder Parameters

NEFSC Protocols

Echo sounder parameters are set relative to the goals of the survey and in some cases are a compromise between data quality and preferred values, where data quality has paramount priority.

Transceiver settings for the Simrad EK500 echo sounder are provided in Table 2. The S_v gain (G_0) is obtained from the echo sounder calibration (Calibration section). Simrad provides the power and two-way integrated beam pattern and these values are not modified unless a transducer is changed. The sound speed and sound attenuation are not modified from the default values for the fall Atlantic herring survey. The bandwidth value ('auto') is set according to the Simrad recommendations. The pulse durations for the 38-kHz and the 120-kHz systems are set equivalently (*i.e.*, the 'medium' 38-kHz pulse duration is equivalent to the 120-kHz 'long' pulse duration) as per the recommendation of Demer et al. (1999) for improving acoustical discrimination of individual targets using multi-frequency methods. The 1 ms pulse duration was chosen for the 38-kHz echo sounder as the optimal setting for the depth ranges encountered during the fall Atlantic herring survey (maximum range of approximately 500 m) and the vertical resolution of the integrated data (1 m). The 'medium' pulse durations of the 12 and 18-kHz systems were chosen to avoid poor performance detected at the 'short' setting.

Table 2. EK500 echo sounder transceiver parameter settings. Ψ is the two-way integrated beam pattern [dB], and α is the sound attenuation [dB m^{-1}]. The pulse length is given as the Simrad setting (Medium or Long) and the duration (given in milliseconds). Note the 12-kHz echo sounder was replace by the 18-kHz echo sounder in 2002.

Frequency [kHz]	Sound Speed [m s^{-1}]	Pulse Length	Bandwidth	Ψ	α	Power [Watts]
12	1500	Medium (3.0)	Auto	-15.8	1	4000
18	1500	Medium (2.0)	Auto	-16.9	3	2000
38	1500	Medium (1.0)	Auto	-15.8	10	1000
120	1500	Long (1.0)	Auto	-20.7	38	1000

The echo sounder is calibrated with the same transceiver settings used during the survey, and the transceiver settings are not modified during the survey.

Other EK500 echo sounder parameters for S_v data collection are provided in Table 3. These parameter settings are common among all frequencies (12, 18, 38, and 120 kHz). Parameters not listed in Table 3 are left to the discretion of the operator and do not affect data collection.

Table 3. EK500 echo sounder S_v data collection parameters.

Parameter	**Setting**
Operation Menu/Ping Auto Start	Off
Operation Menu/Ping Interval	2.0
Operation Menu/Transmit Power	Normal
Operation Menu/Noise Margin	0
Bottom Detection Menu/Minimum Depth	3.0
Bottom Detection Menu/Maximum Depth	550
Bottom Detection Menu/Minimum Level	-50
Log Menu/Mode	Speed
Log Menu/Dist. Interval	1.0
Layer Menu/Super Layer	1
Layer Menu/Layer-1 Menu/Type	Surface
Layer Menu/Layer-1 Menu/Range	500.0
Layer Menu/Layer-1 Menu/Range Start	0.0
Layer Menu/Layer-1 Menu/Margin	0.0
Layer Menu/Layer-1 Menu/Sv Threshold	-90
Layer Menu/Layer-1 Menu/No. of Sublayers	1
All other 'Layer Menu/…/Type'	Off
Ethernet Com. Menu: Local and Remote ETH and IP addresses are set to the appropriate values depending on the computer network.	
Ethernet Com. Menu/Telegram Menu/Remote Control	On
Ethernet Com. Menu/Telegram Menu/Sample Range	500
Ethernet Com. Menu/Telegram Menu/Status	On
Ethernet Com. Menu/Telegram Menu/Parameter	On
Ethernet Com. Menu/Telegram Menu/Annotation	Off
Ethernet Com. Menu/Telegram Menu/Sound Velocity	Off
Ethernet Com. Menu/Telegram Menu/Navigation	On
Ethernet Com. Menu/Telegram Menu/Motion Sensor	Off
Ethernet Com. Menu/Telegram Menu/Depth	1&2&3
Ethernet Com. Menu/Telegram Menu/Depth NMEA	Off
Ethernet Com. Menu/Telegram Menu/Echogram	1&2&3
Ethernet Com. Menu/Telegram Menu/Echo-Trace	1&2&3
Ethernet Com. Menu/Telegram Menu/Sv	Off
Ethernet Com. Menu/Telegram Menu/Sample Angle	Off
Ethernet Com. Menu/Telegram Menu/Sample Power	Off
Ethernet Com. Menu/Telegram Menu/Sample Sv	Off
Ethernet Com. Menu/Telegram Menu/Sample TS	Off
Ethernet Com. Menu/Telegram Menu/Vessel-Log	On
Ethernet Com. Menu/Telegram Menu/Layer	Off
Ethernet Com. Menu/Telegram Menu/Integrator	Off
Ethernet Com. Menu/Telegram Menu/TS Distribution	Off
Ethernet Com. Menu/Telegram Menu/Towed Fish	Off
Ethernet Com. Menu/UDP Port Menu: All values set to 2000.	
Ethernet Com. Menu/Echogram Menu/Range	500

(all values set equally among transceivers)	
Ethernet Com. Menu/Echogram Menu/Range Start	0
Ethernet Com. Menu/Echogram Menu/Auto Range	Off
Ethernet Com. Menu/Echogram Menu/Bottom Range	15
Ethernet Com. Menu/Echogram Menu/Bot. Range Start	10
Ethernet Com. Menu/Echogram Menu/No. of Main Val.	500
Ethernet Com. Menu/Echogram Menu/No. of Bot. Val.	150
Ethernet Com. Menu/Echogram Menu/TVG	20 log R
Serial Com. Menu/Telegram Menu/Format	ASCII
Serial Com. Menu/Telegram Menu/Remote Control	On
Serial Com. Menu/Telegram Menu/Navigation	On
Serial Com. Menu/Telegram Menu/Depth	1&2&3
Serial Com. Menu/Telegram Menu/Depth NMEA	2
Serial Com. Menu/Telegram Menu/Vessel-Log	On
Serial Com. Menu/USART Menu/Baudrate	9600
Serial Com. Menu/USART Menu/Bits Per Char.	8
Serial Com. Menu/USART Menu/Stop Bits	1
Serial Com. Menu/USART Menu/Parity	None
Navigation Menu/Navig. Input	Serial
Navigation Menu/Start Sequence	$GPGLL
Navigation Menu/Separation Char.	002C
Navigation Menu/Stop Character	000D
Navigation Menu/First Field No.	2
Navigation Menu/N. of Fields	4
Navigation Menu/Speed Input	Serial
Navigation Menu/Manual Speed	10
Navigation Menu/NMEA Transfer	On
Navigation Menu/Baudrate	4800
Navigation Menu/Bits Per Char.	8
Navigation Menu/Stop Bits	1
Navigation Menu/Parity	None
Utility Menu/Status Messages	On
Utility Menu/FIFO Output	Off
Utility Menu/External Clock	Off
Utility Menu/Password	0
Utility Menu/Default Setting	No

Software

NEFSC Protocols

The echo sounder firmware version and the post-processing software (SonarData, Echoview) version are documented for every survey.

GPS

NEFSC Protocols

The primary Global Positioning System (GPS) data used for the acoustical surveys are the differential GPS values. PCODE GPS data are used as a secondary source.

Oceanographic Data

NEFSC Protocols

Sea-surface temperature and salinity data are collected continuously during the survey. These are a standard set of data regularly collected by the Scientific Computer System (SCS).

Vertical temperature and salinity (CTD) profiles are conducted at the beginning and end of each transect.

Vertical CTD profiles are also conducted immediately prior to or immediately after every deployment or set of deployments. If multiple deployments are to be conducted in the same area and over a short time frame (e.g., less than 12 hours), whether to conduct a single CTD or multiple profiles is left to the discretion of the scientific watch chief.

The Fisheries Oceanography Investigation (FOI) maintains the CTD instrumentation and is responsible for CTD data management. The FOI provides training for CTD operation at the beginning of each survey ‘leg’. All scientific personnel participate in the training at least once during the survey.

Detection Probability

Techniques

Thresholding

NEFSC Protocols

The S_v data collection threshold for all acoustical frequencies is set at –90 dB for Atlantic herring surveys (this value is set in the ‘Layers’ menu). The –90 dB value was chosen due to the observation that echo amplitudes for juvenile and adult Atlantic herring are sufficiently (30-50 dB) greater than the –90 dB threshold.

The post-processing S_v threshold was chosen for Atlantic herring by evaluating the relationship of S_A as a function of S_v threshold (Figure 1). An S_v threshold of –66 dB was chosen as the optimal value to retain volume backscattering by Atlantic herring while reducing backscatter by other organisms.

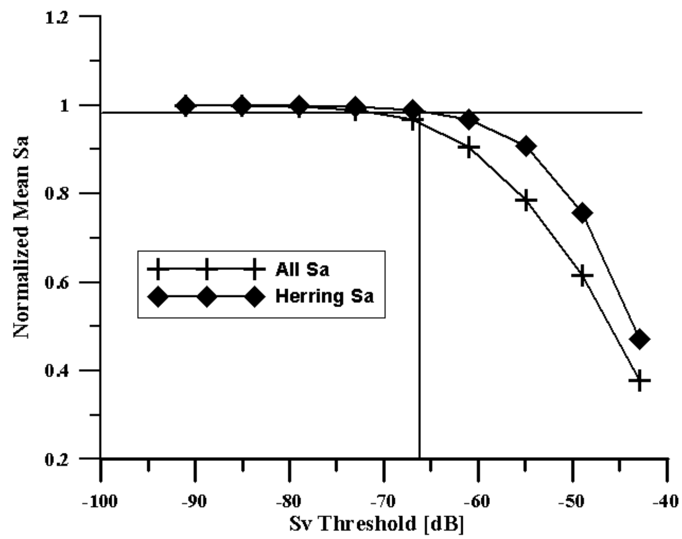

Figure 1. Normalized water column S_A and Atlantic herring S_A as a function of S_v threshold. Data were collected during September 1999 on Georges Bank.

Range

NEFSC Protocols

Currently we do not have protocols to account for range or signal to noise affects.

Acoustic Dead Zones: Near surface and near bottom

NEFSC Protocols

No S_v data are eliminated during data collection.

When post-processing the S_v data, a constant depth below the surface is chosen where data above this depth (i.e., near-surface data) are eliminated from analyses (this depth is commonly called the 'bubble layer'). The minimum depth is set to 10 m for the 18, 38, and 120-kHz echo sounders. The minimum depth was set to 32 m for the 12-kHz echo sounder. The depth for the 18, 38, and 120-kHz systems was chosen based on: 1) the hull-mounted transducers are located approximately 3 m below the surface, 2) the near field of the 38 kHz transducer is approximately 7 m, 3) a consistent depth is desired to compare data among the frequencies, and 4) under normal survey conditions, surface noise (*e.g.*, bubbles) do not penetrate deeper than 10 m. The 32 m depth was chosen for the 12 kHz due to significant 'ring-down' of the 12-kHz transducer in the top 30 m.

During data collection and post-processing of the S_v data, a constant distance above the bottom where data below this depth are eliminated from analyses (this distance is commonly called the 'backstep') is selected. The 'backstep' is set to 0.5 m for all frequencies. This distance was chosen based on observations of the S_v data and the EK500 and Echoview bottom-detection algorithms. EK500 bottom-detection parameters are:

i. Minimum Depth: 5.0 m
ii. Maximum Depth: 500 m (dependent on survey area)
iii. Min. and Max. Depth Alarm: 0.0 m

iv. Bottom Lost Alarm: Off
v. Minimum Level: -50 dB

For post-processing the S_v data, we use Echoview's bottom-detection algorithm to select the echoes from the seabed. Echoview bottom-detection parameters are:

i. Bottom detection algorithm: Maximum Sv with backstep
ii. Minimum Sv for good pick: -50.00 dB
iii. Discrimination Level: -40.00 dB
iv. Backstep range: -0.50 m

The bottom detection is obtained from the 120 kHz data and applied to all frequencies. After the 120-kHz bottom detection has been completed using Echoview's algorithm, all echograms are visually inspected for improper bottom detections. Improper bottom detections are manually corrected using Echoview post-processing software.

As an independent check of the bottom detection algorithm and subsequent visual inspection, a 1 m layer adjacent to and above the bottom detection line (including backstep) is created using Echoview's 'virtual echogram' module. S_v values within this layer greater than an S_v threshold of –40 dB (note this threshold is not equivalent to the post-processing threshold) may indicate improper bottom detections or may indicate backscattering by fish. These Sv values are exported and used to visually inspect echograms for a final determination of improper bottom detection.

Animal Behavior

NEFSC Protocols

Currently we do not have protocols to account for animal behavior effects on S_v measurements.

Vessel Noise and Avoidance

NEFSC Protocols

Sound range measurements were conducted on the FRV Delaware II in January 2003 at the Canadian Naval Sound Range in Halifax, Nova Scotia. A report from the sound range and a summary of the data were generated and are available from the NEFSC fisheries acoustics group.

Currently we do not have protocols for investigating vessel noise effects on S_v measurements.

Currently we do not have protocols for monitoring vessel noise during surveys.

Multiple scattering and shadowing

NEFSC Protocols

Currently we do not have protocols for determining when non-linear scattering effects are significant or for correcting S_v measurements due to multiple scattering and shadowing.

Classification

Techniques

Single Frequency

NEFSC Protocols

The NEFSC utilizes multiple frequencies for subjective classification of Atlantic herring (Refer to the next section).

Multiple Frequency

NEFSC Protocols

Each echo sounder is calibrated according to the calibration protocols (Calibration Section). The 38-kHz data are the primary data for Atlantic herring density and abundance estimates used in assessments. Data processing and post-processing protocols established for the 38-kHz data apply to all frequencies used for analysis. However this does not imply that all parameter settings are equivalent among echo sounders. Calibration and data collection parameters may differ among systems. For near-bottom data, a common bottom-detection line is applied among all frequencies. For near-surface data, the deepest 'bubble layer' will generally limit application of multi-frequency analyses.

Currently we do not have protocols for quantitative multi-frequency analysis in the NEFSC. Atlantic herring are classified qualitatively using subjective interpretation of the S_v backscatter from all frequencies and trawl catch data.

Biological Sampling

Trawls

NEFSC Protocols

For the Fall Atlantic herring survey on Georges Bank, pre-determined trawl locations are defined. These trawl locations were chosen based on spatial distributions of Atlantic herring during acoustical surveys from 1999-2002. Trawl hauls are conducted within ±5 nautical miles (nmi) of these locations. Other trawl locations are determined on an *ad hoc* basis. Selecting *ad hoc* trawl locations is at the discretion of the scientific watch chief, and is based on the experience of the scientific personnel and the goals of the survey.

For other sites in the Gulf of Maine, trawl locations are determined on an *ad hoc* basis. Selecting *ad hoc* trawl locations is at the discretion of the scientific watch chief, and is based on the experience of the scientific personnel and the goals of the survey.

The pelagic trawl used during acoustical surveys is the High Speed Midwater Rope Trawl (HSMRT). The HSMRT used by the NEFSC is modified from Dotson and Griffith (1996). Maintenance details for the HSMRT are given in "NEFSC_midwater_trawl_maintenance.PDF". The chief boatswain is provided a copy of this document before sailing.

Trawl catch data are processed according to the Ecosystems Survey Branch (ESB) protocols (refer to the Bottom Trawl Survey Protocol), with modifications for the acoustical surveys and sampling Atlantic herring. The primary trawl catch processing software is the Fisheries Scientific Computer System (FSCS). The two components of

FSCS that are modified for acoustical surveys are the 'Trawl Event' and the sampling station designation.

The 'Trawl Event' electronically documents meta-data information pertinent to the trawl. The FSCS manual provides standard operating procedures for the trawl event and the bridge officers are responsible for operating the trawl event. Five modifications of the trawl event for acoustical surveys are:

i. The "Station Number" and the "Tow Number" are set equivalent to the acoustical deployment number.
ii. The "Start Event" button is clicked when the net begins streaming.
iii. The "Start Trawl" button is clicked when the doors enter the water.
iv. The "Stop Trawl" button is clicked when the doors come out of the water.
v. The "Stop Event" button is clicked when the net is on the deck.

The ESB defines a 'station' as a coordinated set of activities associated with a trawl. The fisheries acoustics group does not follow this convention. During acoustical surveys, a 'deployment' is defined as a single activity or event, deployment numbers are sequential throughout the entire survey, and each deployment receives a sequential number. For example, a CTD conducted prior to a trawl is given a separate deployment number from the trawl. The start of the mid-water trawl is defined as when the doors enter the water, and the end is defined as when the doors exit the water. This start and end distinctions are due to the fact that the net is able to encounter and catch fish and other organisms as soon as the doors are set.

Procedures for setting and retrieving the pelagic trawl are provided in the "NEFSC_aqstx-biology_manual.doc" document. The manual provides procedures for the bridge and scientific staff.

Net mensuration sensors are attached to the net during trawling activities to: provide real-time evaluation of the net performance, ensure proper net configuration, and document net performance. Net mensuration data are collected with Vemco MiniLog temperature-depth probes, Simrad ITI sensors, and a Simrad FS903 scanning sonar.

Two Vemco minilog temperature-depth probes are attached to the net, one on the headrope and one on the footrope, as the net is being set. The probes record temperature and depth at 2-second intervals. Each probe is initialized immediately prior to the trawl. Upon retrieval of the net, the data are downloaded to a shipboard computer, and downloaded to a shore-based computer at the end of the survey.

Simrad ITI sensors measure door and wing spread, and athwartship location of the net relative to the vessel. The ITI sensors are battery operated, and must be charged prior to sailing and during the survey. Prior to sailing, two ITI sensors are attached to the doors (a 'communication' sensor on one door, and a 'remote' sensor on the other). As the net is being set, two ITI sensors are attached to the wings. Similar to the doors, a communication sensor is placed on one wing, and a remote sensor is placed on the opposite wing. Simrad labels the ITI sensors as '1' and '2'. It is imperative that two sets of '1' or '2' are not used on the same net. Upon retrieval of the net, the wing sensors are removed and stored.

The Simrad FS903 is the primary instrument used for evaluating the real-time performance of the net. A trawl is not to be conducted if the FS903 is inoperable. The FS903 is a 'third-wire' system that contains a scanning sonar and a temperature-depth recorder. The FS903 requires an armored conducting cable and winch. Prior to sailing, the ship's electronic technician will connect the FS903 and ensure that it is operational. As the net is being set, the FS903 is placed in the 'kite' near the headrope, and upon retrieval the FS903 is removed from the kite and stored. Because the FS903 is the primary instrument for determining that the net is properly set, a display is located on the bridge and in the trawl winch operator room.

The ITI and FS903 displays are constantly monitored by scientific and bridge personnel during the trawl to ensure that the net is 'fishing' properly and is not on the bottom. After the net has reached 'fishing' depth, at approximately 5-minute intervals or each time the depth of the net is modified, the data and time (in GMT), vessel speed, shaft RPM, temperature at the net, depth of the headrope, door and wing spreads, vertical mouth opening, and horizontal opening are recorded to a paper form. These data are then entered in a spreadsheet and archived at the conclusion of the survey.

Trawl catch sampling and sub-sampling protocols for length, weight, age, and other biological variables are based on the standard protocols set by the NEFSC – except for Atlantic herring. For more details on the standard protocols refer to the NEFSC Trawl Survey Protocol, and the NEFSC Fisheries Scientific Computing System (FSCS) manual. The catch, including herring, is processed using the FSCS system.

Sampling and sub-sampling Atlantic herring protocols are:

i. Approximately 150 individual Atlantic herring are randomly chosen from the entire herring catch as a sample. If there are fewer than 150 individuals, all herring are sampled.
ii. For all 150 herring, individual lengths and individual weights are measured.
    a. Fish length is recorded as fork length (FL) to the nearest millimeter [mm]. If the electronic board does not measure to the nearest mm, use a manual measuring board.
    b. Fish weight (mass) is recorded to the nearest gram [g].
iii. At least once per survey, fork lengths and total lengths (TL) should be measured, in addition to the other measurements, to maintain a time series of the FL-to-TL relationship.
iv. For 'age&growth', food habits, and maturity data the following sub-sampling is conducted:
    a. One herring per centimeter [cm] length class below 25 cm is sampled.
    b. Three herring per cm length class greater than or equal to 25 cm are sampled.
    c. The cm length class is defined as between 5 mm below and 4 mm above the length class designation. For example, the 25 cm length class is bounded by 245 and 254 mm (24.5 to 25.4 cm).
    d. Only the herring sub-sampled for age&growth are frozen whole for later otolith extraction by the Age and Growth Branch at the NEFSC.
v. At the conclusion of processing the catch, the data are loaded into Oracle.

The document "NEFSC_aqstx-biology_manual.doc" details procedures for biological sampling.

Underwater video.

NEFSC Protocols

Underwater video methods and techniques are currently experimental and currently we do not have protocols for underwater video measurements.

Bottom Tracking

NEFSC Protocols

Refer to the 'Volume Backscattering Measurements->Detection Probability -> Acoustic Dead Zones' section for protocol details.

Performance Degradation

Techniques

Noise

Acoustical

NEFSC Protocols

The ship's electronic technician maintains a list of all acoustical systems on board. This list documents operating frequency, manufacturer, model, and serial number. We have established which systems interfere with the scientific EK500 echo sounders. These systems are the bridge Simrad EQ50 echo sounder (dual 50 and 200 kHz), the bridge Raytheon recording depth sounder (38 kHz), and the Acoustic Doppler Current Profiler (ADCP) operating in 'wideband' mode. After the vessel has left port, the Raytheon recording depth sounder is turned off during acoustical surveys. The ADCP is not operated during acoustical surveys. The 50-kHz signal from the EQ50 has been determined to interfere with the EK500 38-kHz echo sounder. The EQ50 operating mode is switched to '200 kHz only' during acoustical surveys.

Electrical

NEFSC Protocols

Electrical interference has not been an issue during acoustical surveys.

Bubble Attenuation

NEFSC Protocols

Currently we do not have protocols for adjusting S_v measurement due to bubble attenuation during survey operations.

We remove backscattering by surface bubbles that extend below the 'bubble layer' from S_v data during post-processing by encompassing these areas using Echoview regions and defining these regions as 'Bad Data'. The 'bad data' designation eliminates this data from analysis.

Transducer Motion

NEFSC Protocols

Currently we do not have protocols for adjusting S_v measurements due to transducer motion.

Currently we do not have protocols for objective decisions for suspending survey operations based on sea state or vessel motion. The decision to slow the vessel or to suspend operations due to sea-state is based on the judgment of the scientific watch chief.

Bio-fouling

NEFSC Protocols

Prior to sailing, the bridge officers and deck crew often conduct diving operations on the ships. If feasible, the divers are requested to inspect and, if necessary, clean the hull-mounted transducers before each survey.

Considerations

Remediation

In some cases, we are not able to eliminate acoustical interference during data collection (*e.g.*, the Simrad ITI sensors cause 'spikes' in the 38 kHz data during trawl activities). For these data, the noise is manually removed during post-processing using Echoview regions specified as 'Bad Data'. This designation eliminates those data from analysis.

If results of cavitation, bubble attenuation, or transducer motion are observed on any echo sounder (e.g., blank spots in the echogram), the survey is conducted at a slower speed. If the vessel speed drops below 6 knots, survey operations are suspended. The decision to slow the vessel or suspend operations is at the discretion of the scientific watch chief.

Data Management

During the survey, volume backscattering data are stored on the Scientific Computer System (SCS) backup server. Hard drives on this server are in a RAID configuration to minimize the potential for data loss.

S_v data are downloaded to a shore-based computer at the end of each survey 'leg'. Volume backscattering data are archived by the Data Management Service (DMS).

Target Strength (σ_i)

Models

Techniques

Theoretical

NEFSC Protocols

The use of theoretical models is experimental. Currently we do not have protocols for integrating theoretical models in survey estimates.

Empirical

NEFSC Protocols

Currently we do not have protocols for implementing empirical models of Atlantic herring from the Gulf of Maine in survey estimates.

Validation

NEFSC Protocols

Currently we do not have protocols for validating theoretical or empirical models.

Data Collection

Techniques

Echo sounder Parameters

NEFSC Protocols

Simrad EK500 single target detection parameters for the Atlantic herring acoustical surveys are given in Table 4. The parameters are set equivalently among all frequencies. The TS threshold is set to –66 dB, which is a compromise between logistic constraints imposed by the EK500 and detecting Atlantic herring or other organisms. The EK500 limits the number of single target detections to 30 targets per ping. This limit restricts the range at which individual targets can be detected (*i.e.*, when the TS threshold is set at a lower value, the number of single detections reaches the limit at depths shallower than the observed depth of the Atlantic herring. Thus Atlantic herring TS measurements are significantly reduced due to this limitation). The maximum phase deviation, and minimum and maximum echo width parameters are set to the EK500 default values. The maximum beam compensation parameter is set to 3 dB, which allows targets from within the full beam width and eliminates targets outside of the acoustic beam.

Table 4. NEFSC EK500 single target detection parameters.

Frequency [kHz]	TS threshold [dB]	Min. Echo Width	Max. Echo Width	Max. Beam Comp. [dB]	Max. Phase Deviation
12	-66	0.8	1.5	3	4
18	-66	0.8	1.5	3	4
38	-66	0.8	1.5	3	4
120	-66	0.8	1.5	3	4

The EK500 echo sounder firmware version and the parameter values are documented for each survey. For standard survey operations, only the ‘Echo Trace telegram’ data are collected for all frequencies. The ‘Echo Trace’ data are individual targets detected by the EK500. For selected site-specific investigations, the ‘Sample Angle’, ‘Sample Power’, and ‘TS’ telegrams are collected. Advantages to collecting these data are that they can be analyzed in other software packages, such as Echoview or other program languages for in-depth studies of TS measurements. The disadvantage is that these data require much greater data storage (approximately an order of magnitude greater data rates).

Software

NEFSC Protocols

The Echoview version is documented for every survey. When Simrad Sample Angle, Sample Power, or TS telegrams are recorded, the post-processing parameters for single target detection are documented.

In situ data

NEFSC Protocols

Currently we do not have protocols for collecting *in situ* target strength data. The NEFSC is investigating methods and instrumentation for collecting *in situ* target strength data.

GPS

NEFSC Protocols

The primary Global Positioning System (GPS) data used for the acoustical surveys are the differential GPS values. PCODE GPS data are used as a secondary source.

Oceanographic Data

NEFSC Protocols

Sea-surface temperature and salinity data are collected continuously during the survey. These data are a standard set of data regularly collected by the Scientific Computer System (SCS).

Vertical temperature and salinity (CTD) profiles are conducted at the beginning and end of each transect.

Vertical CTD profiles are also conducted immediately prior to or immediately after every deployment or set of deployments. If multiple deployments are to be conducted in the same area and over a short time frame (e.g., less than 12 hours), whether to conduct a single CTD or multiple casts is left to the discretion of the watch chief.

The Fisheries Oceanography Investigation (FOI) maintains the CTD instrumentation and is responsible for CTD data management. The FOI provides training for CTD operation at the beginning of each survey ‘leg’. All scientific personnel participate in the training at least once during the survey.

<u>Detection Probability</u>

Techniques

NEFSC Protocols

The beam width and directivity response function for each transducer are provided by the transducer manufacturer (Simrad) and are documented for each survey. During calibration exercises, beam pattern measurements are evaluated for proper echo strength compensation.

Thresholding

NEFSC Protocols

The single target discrimination threshold is set at –66 dB. This setting is a compromise between logistic constraints imposed by the EK500 and an optimal threshold to obtain TS measurements of Atlantic herring and other organisms. The 'TS Measurements -> Echo Sounder Parameter Settings' details the justification for this parameter value.

Acoustic Dead Zones: Near Bottom and Near Surface

NEFSC Protocols

Near-surface and near-bottom limitations are equivalent for target strength and S_v data. The 'Volume Backscattering Measurement->Detection Probability->Acoustic Dead Zones' section provides detailed protocols.

Animal Behavior

NEFSC Protocols

Currently we do not have protocols for incorporating animal behavior in target strength measurements.

Vessel Noise

NEFSC Protocols

The 'Volume Backscattering Measurements->Detection Probability->Vessel Noise and Avoidance' section provides details on vessel noise. Currently we do not have protocols for incorporating vessel noise in analysis of TS measurements.

Density Requirements

NEFSC Protocols

Currently we do not have protocols for incorporating density dependencies on target strength measurements.

Single Frequency

NEFSC Protocols

Currently we do not have protocols for incorporating single frequency methods in analyzing target strength data.

Multiple Frequency

NEFSC Protocols

Currently we do not have protocols for incorporating multiple frequency methods in analyzing target strength data. We are investigating the potential for incorporating multi-frequency methods described by Demer et al. (1999) to improve target strength measurements.

Classification

Techniques

Single Frequency

NEFSC Protocols

Currently we do not have protocols for classification of individual targets using single frequency target strength data.

Multiple Frequency

NEFSC Protocols

Currently we do not have protocols for classification of individual targets using multiple frequency target strength data.

Biological Sampling

Trawls

NEFSC Protocols

Verification of the species composition of individual targets is equivalent to methods used for S_v data. The ‘Volume Backscattering Measurements->Classification->Biological Sampling->Trawls’ section provides detailed protocols for biological sampling.

Underwater video.

NEFSC Protocols

The use of underwater video methods and instrumentation are experimental. Currently we do not have protocols for underwater video methods.

Bottom Tracking

NEFSC Protocols

Seabed detection protocols are equivalent for target strength and S_v data. Detailed protocols are provided in the ‘Volume Backscattering Measurements->Detection Probability->Acoustic Dead Zones’ section.

Performance Degradation

Techniques

Noise

Acoustical

NEFSC Protocols

Acoustical noise protocols are equivalent for the target strength and S_v data. The ‘Volume Backscattering Measurements->Performance Degradation-Noise->Acoustical’ section provides detailed methods.

Electrical

NEFSC Protocols

Electrical noise protocols are equivalent for the target strength and S_v data. The 'Volume Backscattering Measurements->Performance Degradation->Noise-Electrical' section provides detailed methods.

Bubble Attenuation

NEFSC Protocols

Currently we do not have protocols for adjusting or correcting target strength measurements due to bubble attenuation. During post-processing, backscattering by surface bubbles is removed from TS data using Echoview regions defined as 'Bad Data'. This designation eliminates these data from analysis.

Transducer Motion

NEFSC Protocols

Currently we do not have protocols for adjusting TS measurements due to transducer motion.

Currently we do not have protocols for objective decisions for suspending survey operations based on sea state or vessel motion. The decision to slow the vessel or suspend operations is at the discretion of the scientific watch chief.

Bio-fouling

NEFSC Protocols

Prior to sailing, the bridge officers and deck crew often conduct diving operations on the ships. If feasible, the divers are requested to inspect and, if necessary, clean the hull-mounted transducers before each survey.

Considerations

Remediation

If results of cavitation, bubble attenuation, or transducer motion are observed on any echo sounder (e.g., blank spots in the echogram), the survey is conducted at a slower speed. If the vessel speed drops below 6 knots, survey operations are suspended. The decision to slow the vessel or suspend operations is at the discretion of the scientific watch chief.

Data Management

During the survey, target strength data are stored on the Scientific Computer System (SCS) backup server. Hard drives on this server are in a RAID configuration to minimize the potential for data loss.

Target strength data are downloaded to a shore-based computer at the end of each survey 'leg'. Target strength data are archived by the Data Management Service (DMS).

Sampling

Survey Design (A_i)

Techniques

Vessel Speed

NEFSC Protocols

Survey vessel speed while conducting transects is optimally 10 knots. The minimum vessel speed for conducting transects is 6 knots. If excessive vessel motion is observed at six knots, operations should be suspended until the sea state reduces.

Currently we do not have objective criteria for reducing vessel speed or suspending survey operations based on excessive performance degradation.

GPS

NEFSC Protocols

The primary Global Positioning System (GPS) data used for the acoustical surveys are the differential GPS values. PCODE GPS data are used as a secondary source.

Numerical Density to Biomass Density (D_i)

Techniques

Target Strength to Length Regression

NEFSC Protocols

Interpretation and derivation of target strength to length regressions are beyond the scope of these protocols. Target strength data collection methods are detailed in the 'Target Strength Measurements' section. Fish length measurements and biological data collection methods are detailed in the 'Volume Backscattering Measurements -> Classification->Biological Sampling->Trawls' section.

Length-Weight Regression

NEFSC Protocols

Interpretation and derivation of length-weight regressions are beyond the scope of these protocols. Fish length and weight measurements and biological data collection methods are detailed in the 'Volume Backscattering Measurements->Classification -> Biological Sampling->Trawls' section.

Oceanographic Data

Techniques

CTD profiles

NEFSC Protocols

Fisheries Oceanography Investigation (FOI) maintains the CTD instrument manufacturer, identification number, firmware version, processing software and version and is responsible for calibrating and maintaining CTD instrumentation.

Water samples are collected once every 24 hours and the water stored for laboratory analysis of salinity. These data are used to ensure data quality throughout the survey.

Vertical temperature and salinity (CTD) profiles are conducted at the beginning and end of each transect.

Vertical CTD profiles are also conducted immediately prior to or immediately after every deployment or set of deployments. If multiple deployments are to be conducted in the same area and over a short time frame (e.g., less than 12 hours), whether to conduct a single CTD or multiple casts is left to the discretion of the watch chief.

Data collection and archiving protocols are established by FOI. Prior to each survey, the FOI conducts training for operating the CTD hardware and software. All scientific personnel involved with collecting CTD data attend training at least once during the survey.

Surface temperature and salinity

NEFSC Protocols

Sea-surface temperature and salinity sensors and data are part of the Scientific Computer System (SCS). NOAA Marine and Aviation Operations (NMAO) are responsible for maintaining on-board instrumentation and sensors. The ship's electronic technicians document the manufacturer, model numbers, and identification numbers of temperature and salinity sensors.

For acoustical surveys on the FRV Delaware II, the hull-mounted sensors at 3-m depth provide the primary sea-surface temperature and salinity data.

Scientific Computer System (SCS)

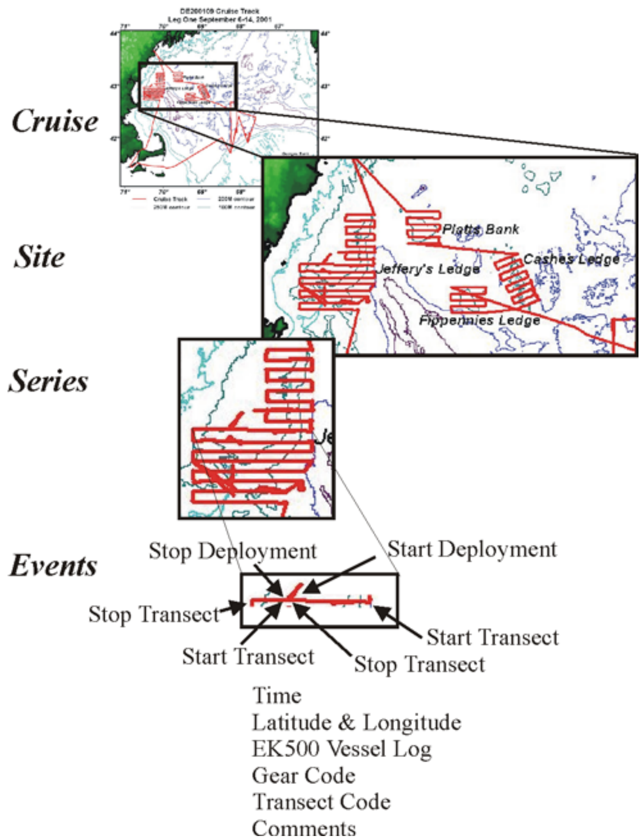

Figure 5. Pictorial overview of the hierarchical NEFSC acoustical event log.

Techniques

Event Log

NEFSC Protocols

The Scientific Computer System (SCS) is a shipboard system that logs data from electronic sensors throughout the vessel. Within the SCS framework, SCS event logs are created for specific surveys. The acoustical event log electronically documents events in order to coordinate the acoustical data with other scientific operations, such as CTD and trawl deployments. At the conclusion of a survey, the event log data are audited and entered in an Oracle database. In addition to the electronic log, a ‘hardcopy’ paper form is filled out with equivalent information. This paper log is updated each time the SCS event log is updated.

Prior to sailing, an acoustical SCS event log is created by modifying an existing acoustical event log template. The survey code is set to the current survey, and the event log is saved to a new file. The file name of the SCS acoustical event log is used to define the directory where the data are stored.

During the survey, the acoustical SCS event log is constantly monitored and updated for all events by the scientific personnel. The watch chief is responsible for event log quality and for training personnel in the use of the event log.

SCS data

NEFSC Protocols

The following sensor data are pertinent to the acoustical survey and should be collected:

a. Date and time (GMT)
b. GPS (differential and PCODE)
c. Doppler Speed Log (bridge speed log)
d. Motion Sensor

Prior to sailing, the ship's electronic technician is contacted to ensure these data are stored. At the end of the survey, copies of the SCS data are requested from the ship's electronic technician.

Data Management

At the conclusion of each 'leg' of the survey, the SCS and SCS event log data are downloaded to a shore-based computer for storage and archiving. The SCS data are archived by the ship's electronic technician, the NEFSC, and the fisheries acoustics group.

Archival and management of CTD data are the responsibility of the Fisheries Oceanography Investigation.

Modifications to Protocols

Changes to operational protocols will be at the discretion of the NEFSC Science Director who may approve such changes directly or specify a peer review process to further evaluate the justification and impacts of the proposed changes.

References

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